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Summary with Implications

A metabolism trial was conducted to evaluate protein from modified distillers grains plus solubles (MDGS) in finishing diets on nutrient digestibility and ruminal fermentation characteristics. Isolated protein from corn was not different than MDGS for dry matter, organic matter, or neutral detergent fiber digestibility. However, steers fed MDGS tended to have lower total tract organic matter digestibility compared to corn and protein from corn. Protein had greater total tract organic matter and starch digestibility than MDGS. Protein from corn did not contribute towards the lower digestibility of MDGS. Protein is more easily digestible than the other components in distillers grains plus solubles.

Table 1. Composition of dietary treatments containing protein components of distiller grains fed to steers.

	Treatment			
Item[1]	CON[2]	40DGS	HIGH-CGM	CGM-CDS
Ingredient, % DM[3]				
DRC	76.5	40.0	62.5	52.5
MDGS	-	40.0	-	-
Corn Silage	15.0	15.0	15.0	15.0
CGM	-	-	17.5	17.5
CDS	-	-	-	10.0
SBM	3.5	-	-	-
Supplement[4]	5.0	5.0	5.0	5.0
Nutrient Composition, %				
CP	12.5	18.5	19.6	22.1
NDF	14.8	26.1	13.6	13.2
Fat	3.6	6.5	3.5	3.8
Starch	55.6	32.6	48.8	42.6

[1]All values presented on a DM basis.
[2]Supplemented with urea at 1.405% of diet to meet the RDP requirement.
[3]DRC = dry-rolled corn; MDGS = Modified distillers grains plus solubles; CGM = corn gluten meal; CDS = condensed distillers solubles; SBM = soybean meal.
[4]Beef trace mineral contained 10%Mg, 6% Zn as ZnO, 4.5% Fe as $FeSO_4$, 2% Mn as MnO, 0.5% Cu as $CuSO_4$, 0.3% I as $Ca(IO_3)2(H_2O)$, and 0.05% Co as $CoCO_3$. Vitamin A, D, and E premix contained 1,500 IU vitamin A, 3,000 IU vitamin D, and 3.7 IU vitamin E per g. Rumensin formulated to provide 375 mg·steer·d^{-1} monensin (Rumensin; Elanco Animal Health, Greenfield, IN). Tylan forumated to provide 90 mg·steer·d^{-1} tylosin (Tylan; Elanco Animal Health).

Introduction

As advances in technology continue in the ethanol industry, isolating and separating components of distillers grains plus solubles (DGS) may become prevalent, which changes potential use of DGS in feedlot diets. Establishing the contributions of individual components (i.e. protein, fiber, fat) of distillers grains will help beef cattle producers determine the value of distillers grains as it changes. The protein component of DGS had a similar feeding value as DGS when included at 40% (*2016 Nebraska Beef Cattle Report,* pp. 132–134). No data has been reported on the impact of protein from distiller grains on site and extent of total tract nutrient digestibility. The objective of these experiments were to evaluate protein from DGS on site and extent of nutrient digestibility; and ruminal pH.

Procedure

Experiment 1

Six duodenally fistulated crossbred steers (837 lb initial BW; SE = 110) were utilized in an unbalanced 6 × 6 row-column design, with six periods and four treatments (Table 1). The control (CON) treatment contained 76.50% dry-rolled corn (DRC), 15.00% corn silage, 3.50% soybean meal, 3.55% supplement, and 1.41% urea. Second treatment (40DGS) contained 40.00% DRC, 40.00% modified distillers grains plus solubles, 15.00% corn silage, and 5.00% supplement. The third treatment (HIGH-CGM) contained 62.50% DRC, 17.50% corn gluten meal (CGM), 15.00% corn silage, and 5.00% supplement. The fourth treatment (CGM-CDS) replaced 10% of DRC from the HIGH-CGM diet with condensed distillers solubles. In the experimental diets, the protein portion of modified distillers grains plus solubles (MDGS) was mimicked by CGM to provide similar RUP as 40% MDGS. Corn gluten meal is from wet milling of corn grain and is high in protein (65–75 % CP; 60% of CP is RUP). In addition to CGM, 10% condensed distillers solubles (CDS) was added to HIGH-CGM (CGM-CDS) to compare to 40DGS diet. Diets were formulated to provide 375 mg/steer of Rumensin® (Elanco Animal Health) and 90 mg/steer of Tylan® (Elanco Animal Health) daily.

Steers were individually housed in pens equipped with slatted floors and given *ad litbitum* access to feed and water. Samples

Table 2. Effects of excess rumen ungradable protein from distillers grains in finishing steers diets on intake and total tract digestibility (Experiment 1).

	Treatments					
Item	CON[1]	40DGS[2]	HIGH-CGM[3]	CGM-CDS[4]	SEM	*P*-value
Steers, n	7	8	8	7	-	-
DM						
Intake, lb/d	15.0[c]	17.3[a]	15.6[bc]	16.5[ab]	1.2	0.08
Digestibility, %	79.6	74.4	82.3	83.1	3.1	0.16
OM						
Intake, lb/d	14.5	16.4	15.1	15.7	1.1	0.17
Digestibility, %	81.0	76.0	83.4	84.5	2.8	0.14
NDF						
Intake, lb/d	2.2[b]	4.5[a]	2.1[b]	2.2[b]	0.2	<0.01
Digestibility, %	47.9	59.3	48.0	55.9	7.3	0.53
Starch						
Intake, lb/d	8.4[a]	5.7[c]	7.8[a]	7.1[b]	0.5	<0.01
Digestibility, %	92.1[a]	86.6[b]	94.8[a]	92.1[a]	1.3	<0.01

[a,b,c]Means within a row with different superscripts differ ($P \leq 0.10$).
[1]Control (CON) treatment containing 76.5% dry-rolled corn (DRC), 15.0% corn silage, 3.5% soybean meal, and 5.0% supplement.
[2]Modified distillers treatment containing 40.0% DRC, 40.0% modified distillers grains plus solubles, 15.0% corn silage, and 5.0% supplement.
[3]Treatment formulated to mimic protein portion of 40DGS with corn gluten meal (CGM) at 17.5%, 62.5% DRC, 15.0% corn silage, and 5.0% supplement.
[4]Treatment formulated to mimic protein portion of 40DGS with the addition of corn gluten meal at 17.5% and condensed distillers solubles at 10.0%, 52.5% DRC, 15.0% corn silage, and 5.0% supplement.

Table 3. Effects of excess rumen ungradable protein from distillers grains in finishing steers diets on ruminal and post-ruminal digestibility (Experiment 1 and Experiment 2).

	Treatment					
Item	CON[1]	40DGS[2]	HIGH-CGM[3]	CGM-CDS[4]	SEM	*P*-value
Steers, n	4	4	6	5	-	-
DMI, lb/d	15.0[c]	17.3[a]	15.6[bc]	16.5[ab]	1.2	0.08
OM						
Ruminal digestibility, %[5,6]	54.7	59.7	58.4	58.1	4.9	0.90
Postruminal digestibility, % entering	61.3	47.7	64.0	69.4	6.2	0.18
NDF						
Ruminal digestibility, %	44.6	65.9	51.1	49.2	7.1	0.35
Starch						
Ruminal digestibility, %[6]	71.2	69.3	76.0	76.2	6.2	0.35
Postruminal digestibility, % entering	60.0	46.6	69.9	68.7	17.9	0.59

[a,b,c]Means within a row with different superscripts differ ($P < 0.10$).
[1]Control (CON) treatment containing 76.5% dry-rolled corn (DRC), 15.0% corn silage, 3.5% soybean meal, and 5.0% supplement.
[2]Modified distillers treatment containing 40.0% DRC, 40.0% modified distillers grains plus solubles, 15.0% corn silage, and 5.0% supplement.
[3]Treatment formulated to mimic protein portion of 40DGS with corn gluten meal (CGM) at 17.5%, 62.5% DRC, 15.0% corn silage, and 5.0% supplement.
[4]Treatment formulated to mimic protein portion of 40DGS with the addition of corn gluten meal at 17.5% and condensed distillers solubles at 10.0%, 52.5% DRC, 15.0% corn silage, and 5.0% supplement.
[5]Calculation of apparent vs. true used data from samples collected from ruminally cannulated steers to account for bacterial cells flowing into the duodenum.
[6]Caculated using assumed purine:N ratio of 0.3 from Cooper et al. (2002).

of individual ingredients were taken prior to mixing diets, ground through a 1-mm screen, and analyzed for OM, CP, NDF, fat, and starch to calculate nutrient composition of dietary treatments (Table 1).

Each period consisted of 21 days with 16 days for diet adaptation followed by 5 days of collections. Fecal output was estimated by top dressing titanium dioxide (TiO_2; 10 g/day) at time of feeding for the entire period. Duodenal and fecal samples were collected from day 17 to 21 at 0800, 1200, 1600 hours and analyzed for DM, OM, NDF, and starch. Nutrient digestibility was determined by analyzing duodenal and fecal samples for titanium dioxide.

Nutrient digestibility and intake data were analyzed using the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). Steer within period was the experimental unit. Steer was included in the random statement. The model included treatment and period as independent fixed effects.

Experiment 2

Six ruminally fistulated crossbred steers (771 lb initial BW; SD = 95) were utilized in an unbalanced 6 × 6 row-column design, with six periods and four treatments (Table 1). Each period consisted of 14 days with 11 days for adaptation followed by collections from day 12 to 14. Experiment 2 was performed in order to measure ruminal pH and correct for microbial cell flow into the duodenum for Exp 1.

Wireless pH loggers were placed in the rumen on day 7, prior to feeding, and recorded pH measurements every minute until day 14 of each collection period. Samples of whole rumen contents were taken from the ventral portion of the rumen on day 14, blended into a homogenous mixture, strained through 4 layers of cheesecloth, and centrifuged to isolate bacterial cells.

Data for average ruminal pH were analyzed as a repeated measure using the MIXED procedure of SAS. Time within day was the repeated measure. The model included day, time, treatment, and all their interactions, in addition to period as an independent fixed effect.

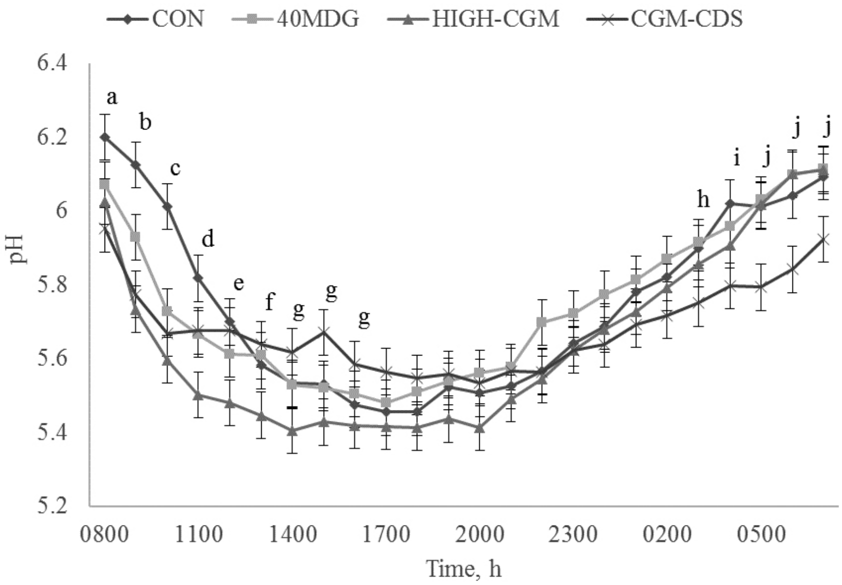

Figure 1. Ruminal pH of cattle fed 4 different dietary treatments was monitored over 6 periods. The control (CON) treatment contained 76.50% dry-rolled corn (DRC), 15.00% corn silage, 3.50% soybean meal, 3.55% supplement, and 1.405% urea. The 40DGS treatment contained 40.00% DRC, 40.00% modified distillers grains plus solubles, 15.00% corn silage, and 5.00% supplement. The HIGH-CGM treatment contained 62.50% DRC, 17.50% corn gluten meal (CGM), 15.00% corn silage, and 5.00% supplement. The CGM-CDS treatment replaced 10% of DRC from the HIGH-CGM diet with condensed distillers solubles. There was an hour × treatment interaction ($P < 0.01$). Treatment differences ($P < 0.05$) within time points are marked with a letter (a, b, c, d, e, f, g, h, i, and j) to signify statistical differences between treatments within that time point. Time points marked with an "a" indicate that the CON treatment had the greatest pH and HIGH-CGM and CGM-CDS had the lowest. The 40DGS treatment was intermediate. Time points marked with a "b" indicate that the CON treatment had the greatest pH and HIGH-CGM and CGM-CDS treatments were the lowest. The 40DGS treatment had a greater pH than the HIGH-CGM and CGM-CDS treatments. Time points marked with a "c" indicate that the CON treatment had the greatest pH and the remaining 3 treatments are the same. Time points marked with a "d" indicate that the CON had the greatest pH and the HIGH-CGM treatment had the lowest. The 40DGS treatment had a greater pH than the HIGH-CGM, and the CGM-CDS treatment was intermediate between CON and 40DGS. Time points marked with an "e" indicate that the CON and CGM-CDS treatments had the greatest pH and the HIGH-CGM treatment had the lowest. The 40DGS treatment was intermediate. Time points marked with an "f" indicate that 40DGS and CGM-CDS treatments had the greatest pH and the HIGH-CGM treatment had the lowest. The CON treatment was intermediate. Time points marked with a "g" indicate that the HIGH-CGM treatment had the greatest pH and the CGM-CDS treatment had the lowest. The CON and 40DGS treatments were intermediate. Time points marked with an "h" indicate that the 40DGS treatment had the greatest pH and the CGM-CDS treatment had the lowest. Time points marked with an "i" indicate that the CON treatment had the greatest pH and that the CGM-CDS treatment had the lowest. Time points marked with a "j" indicate that CON, 40DGS, and HIGH-CGM treatment had a greater pH than the CGM-CDS treatment.

Results

Experiment 1

Nutrient intake and digestibility data are presented in Table 2. Dry matter intake was greater ($P = 0.08$) for 40DGS compared to HIGH-CGM and CON, but not different than CGM-CDS. Organic matter intake was not different ($P = 0.17$) among treatments. However, cattle fed 40DGS had numerically greater OM intake compared to CON. Neutral detergent fiber intake was greater ($P < 0.01$) for 40DGS than all other treatments. The 40DGS diet had approximately twice the NDF content of CON, HIGH-CGM, and CGM-CDS (26.1 vs. 14.8, 13.6, and 13.2% NDF; respectively). Starch intake was greatest ($P < 0.01$) for CON and HIGH-CGM with CGM-CDS greater than 40DGS. Replacing 10% of DRC with CDS reduced the starch content in the diet by 6.2% and subsequently lowered starch intake by 9.9%.

There was no difference ($P = 0.16$) in total tract DM digestibility among treatments, but 40DGS was numerically lower than all other treatments. A similar relationship was observed for total tract OM digestibility, which tended to be impacted ($P < 0.14$) by treatment. Cattle consuming 40DGS tended to have lower total tract OM digestibility compared to cattle fed CON, CGM, and CGM-CDS. There was no difference in total tract NDF digestibility ($P = 0.53$) among treatments. Steers consuming 40DGS and CGM-CDS had numerically greater total tract NDF digestibility compared to CON and HIGH-CGM. Total tract starch digestibility was lower ($P < 0.01$) for 40DGS compared to other treatments, which were not different. Distillers grains plus solubles contains less starch as a result of starch fermentation for ethanol production. The small amount of starch available in DGS may be difficult to access and have lower digestibility by the animal, as well as microbes, because the ethanol plant already exposed the starch to enzymes produced by yeast and other microbes during ethanol production.

Ruminal and post-ruminal OM, NDF, and starch digestibility were not different ($P > 0.18$) among treatments. Ruminal NDF digestibility was not different ($P = 0.35$) among treatments. However, cattle consuming 40DGS had numerically greater ruminal NDF digestibility compared to CON, HIGH-CGM, and CGM-CDS as a result of different sources of NDF. Post-ruminal OM digestibility did not differ ($P = 0.18$) among treatments. Cattle consuming 40DGS had numerically lower post-ruminal OM digestibility compared to cattle consuming CON, HIGH-CGM, and CGM-CDS.

Experiment 2

Previous research has reported that cattle consuming finishing diets with DGS tend to have lower ruminal pH compared to corn-based finishing diets. Results from this experiment support those findings. From time of feeding until 3 hours post-feeding cattle consuming CON had the greatest ruminal pH compared to the byproduct-based diets. Cattle consuming CGM-CDS did not recover to a similar pH as CON, 40DGS, and CGM 5 hours pre-feeding up to time of feeding.

In conclusion, cattle consuming distillers grains plus solubles had lower OM digestibility, which agrees with previous research. The protein from corn did not contribute towards the lower digestibility of MDGS. Protein was more readily digestible than the other components in distillers grains plus solubles.

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